

REMARKS

Claim 7 has been amended to cure the objections raised by the Examiner

The limitation relating to minimizing pattern distortion has been recited positively in the body of the claims where pertinent. This limitation has been removed from the preamble of the claims.

The limitations of using a closed mold, of forming a soft or flexible elastomeric stamp, of preventing permanent shrinkage and of using specific polysiloxane oligomers-siloxane monomer elastomer reactive mix have been incorporated into the body of the claims with this amendment. These limitations are not found in the prior art.

The Examiner is respectfully requested to reconsider the rejection of Claims 1, 2, 5 - 8, and 10 under 35 U.S.C. 103(a) as being unpatentable over Kim, et al.(U.S. Patent 6,355,198) in view of Rosato's Injection Molding Handbook (3rd Edition).

The object of the present invention is to form a microcontact printing stamp which possesses a minimum degree of printing distortion. The method of making the improved stamp of the present invention which stamp has a pattern for microcontact printing utilizes the siloxane composition noted above, wherein the siloxane composition is cured to fix its geometry while at or near the intended final use temperature, followed by a higher temperature step to harden the siloxane composition, without substantially inducing geometry changes to the stamp and the pattern.

Applicant teaches that the pattern fabricated onto the stamp should represent in detail the desired pattern intended to be printed. While this concept may appear in general to be obvious, the extraordinary detail that must be conveyed with microcontact printing makes this faithful representation easier to state as a goal than to realize in practice. Kumar et al. do not form such

an improved article.

The stamp, once made, must have mechanical properties, such as elastic modulus, that allow handling during printing, and minimum additional distortion from the stresses incurred during printing contact. While it is possible to do either separately, it has proven to be a severe fabrication challenge to achieve both simultaneously. Kim, et al. do not form such an improved article.

The two phase cure process and the maintenance of precise dimensions throughout the curing sequences is now recited in Claim 1.

The present invention comprises a simple technique with respect to microcontact printing stamps, to achieve both the required dimensional integrity for pattern faithfulness and desired mechanical properties, primarily high elastic modulus. It teaches that with the vinyl addition type siloxane precursor mixtures (and others), where crosslinking (curing) can take place at either room temperature or higher temperature, a two-step cure produces the desired combination of properties.

The first step is a room temperature cure, since generally room temperature is the condition at which the stamp will be ultimately used. The stamp is allowed to crosslink at room temperature for some period, for example one week. This one week curing is contrary to the 30 minute cure disclosed by Kumar at column 18, line 62 as cited by the Examiner. During this period of time, the stamp crosslinks and fixes the overall stamp geometry and the printing pattern in a manner far superior to and not contemplated by Kumar, et al.

After this curing step is completed, the second step commences wherein the stamp is brought to a much higher temperature, of between about 50 °C and 120 °C, at which temperature a further cure continues thus attaining a higher elastic modulus. Upon cooling back to room temperature, the original pattern is restored without distortion and the stamp has the desired

higher modulus.

The two-step processing described above is used with the intention of using the first step to establish the precise dimension of the molded pattern. The step establishes not just the relative geometry, but also the resulting dimension by being held at a precise temperature within an enclosed mold. Then, once this dimension has been irrevocably established, the material is heated to a higher temperature for hardening.

Even though the material will (and does) expand during the higher temperature curing, it will (and does) shrink back to its original dimension again after cooling to the final use temperature.

With respect to the Kim, et al. reference, not only does this patent deal with an entirely different process, but in the disclosure of the two-step curing process found on column 10, (lines 1 -25) it is clear that their teaching is very different from the teaching of the present invention. Kim, et al. disclose the curing of a molded part in two steps where the purpose of the first step is to harden it sufficiently only to become self-supporting so that it can be removed from the applicator without losing it's form, to allow handling and retain its shape during further hardening. This disclosure is merely the typical purpose of a prebake - to establish a general shape that can be maintained.

This reference says nothing about maintaining a precise dimension. Shape is NOT dimension. Most assuredly the Kim, et al. parts will undergo significant shrinkage during the higher temperature hardening (as does Kumar, et al.'s). The method of the present invention prevents exactly this and differs in this way from Kumar, et al., Kim, et al., and other typical 2-step curing processes. Applicants has added language to Claim 1 which defines that the system keeps a precise dimension throughout curing.

Kim, et al. is a "shot gun" type disclosure. It appears from a review of the reference that

if a polymer resulting from one or more of the catalog of monomers cited therein has the appropriate structure, it is allegedly suitable for use in their invention. Kim, et al. discloses in general terms the many different materials of a sol-gel forming type. Typical examples include SiO_2 (quartz), ZnO , PbScTaO_3 , etc., but not elastomeric organic/inorganic polymers of the siloxane type. These are very different materials from the siloxane rubber disclosed and now claimed by Applicant.

The Examiner has rejects claims 1-8 and 10 on the basis of Kim and Rosato and cites column 4, lines 36-54 which states NOTHING about minimizing pattern distortion, a stated object of the present invention. Rather, Kim simply states that a precursor fluid is molded into a form by taking on the pattern of indentations etched into the surface of a wafer.

Further, the Examiner cites column 10, lines 12-17 of Kim as rendering the invention obvious. With respect to this cite, there are two important distinctions between the instant invention and Kim.

Kim teaches a preharden of the fluid precursor against the pattern on the wafer - but then REMOVES the article from contact with the wafer once it is hard enough to be "self supporting" before the final hardening. This step is insufficient as stresses induced in the handling during such a removal process are enough to induce pattern distortions significant to manufacturing; but these distortions are not obvious until mapped by automated pattern mapping instrumentation. Thus, the inventors (Kim, et al.) who were obviously working on a small scale did not realize or anticipate the need to leave the article, suitable for commercial use, in the mold (or ON the patterned surface in the Kim case, since Kim was not using an enclosed mold as does Applicant.)

Kim does not teach an enclosed mold like Applicant claims which is important for elimination of bubbles and for exact definition of stamp thickness etc.

The Examiner cites column 44 lines 23-27 with respect to molding an elastomer reactive

mix into a mold, curing from an hour to a week etc.

Respectfully, the Examiner is mistaken with respect to this point as the Kim reference patent is referring to an entirely different process at this point in the patent.

Kim is discussing the molding of a sol-gel type process to transfer patterns to silica FROM, NOT to a siloxane elastomer. Such processes of drying very slowly at one temperature before subjecting the part to a higher temperature for sol-gel reactive mixtures is understandable but Kim is NOT speaking about polymer curing in the reference.

Applicant uses totally different chemistry resulting in a hard silica pattern, not a soft polymer elastomer for which such multistep and long-time cures are not known. The very use of the word "drying" distinguishes the Kim disclosure from Applicant's invention as reactive polymers do not dry at all. They cure. Sol-Gel processes (which are not polymers) require very slow drying which is well known in the art. Indeed, sol-gel drying is an art/science all to itself and often involves use of techniques like freeze-drying or supercritical CO₂ extraction followed by slow drying.

Applicant respectfully emphasizes that the Kim sol-gel process as taught therein bears no relation to Applicant's slow multi-stepped curing in mold for the entire curing time period.

While sol-gel processing is sometimes called "polymerization," the reaction mechanism is such that small molecules react into a 3-dimensional network, so that essentially an inorganic silica (quartz-like) species is formed - NOT a flexible elastomer stamp. Applicant has now defined his resultant product in Claim 1 as a "flexible soft elastomeric stamp."

In the Office Action, the Examiner cites column 4, line 48 of Kumar. The Examiner is respectfully requested to note that the Kumar reference does not refer to registration within microns over many inches.

In the Office Action, reference was made to column 44 of Kim, lines 1-3 and lines 32-47 saying a microelectronic pattern is disclosed. Again, this disclosure is relevant for a silica type material from sol-gel process, not for the soft elastomer stamp claimed by Applicant.

In the Office Action, the Examiner (regarding claim 10) acknowledges that Kim was not talking about “soft siloxane materials,” but that in combination with Kumar it would be obvious.

It is not obvious that the extraordinarily fine patterning claimed in Claim 1. et seq., can be extended from the silica type systems of Kim to the cruder type systems of Kumar - unless Applicant’s methodology were used to bridge the gap.

Kumar et al acknowledge that their process is imperfect where they state that their (imperfect) process does cause significant shrinking of the pattern (see column 8, lines 15-30). Kumar, et al. concede that their process does not produce a reproducible product and they concede that they have no control over obtaining reproducible results by rationalizing that the shrinking which is inherent in their process can have advantages because it results in further miniaturization.

By way of contrast, Applicant unequivocally states (as it is his objective) (and now claims in Claim 1 as to “shrinkage”), that the advantage of his invention is that he is able to make the desired pattern at the exact planned-for dimension, and concurrently, he offers a way to prevent the permanent shrinkage of the formed article which is inherent in the prior art reference to Kumar, et al.

More specifically, with respect to the processing method of Kumar, et al., there are differences which result in a finished product which is a different in kind rather than degree. Kumar, et al. disclose that they first allow the precursor material which is to be formed into the elastomeric stamp to set in the mold for about an hour at room temperature before inserting the

mold into the oven. This step, which is a “precure” step, is only superficially similar to the instant process. During the one hour precure step of detailed by Kumar, et al. a modification of the viscosity of the precursors, e.g., the Sylgard and similar systems discussed, will occur. This modification of precursor may provide some handling benefits; e.g., not having the precursor solution flow out of the mold while lifting and positioning the mold in the oven. It is essential to note however, that the dimensions of the Kumar, et al. pattern are not fixed during the mere 1 hour precure at ambient temperature.

In the method of the present invention, the mold is filled with precursor material and this mold/precursor remains at a precisely controlled end-use temperature for many days or up to a week. This establishes the final cured dimensions of the microcontact printing stamp by having allowed a great majority of crosslink reactions to take place at that final use temperature. The final high temperature reaction cures and hardens the material but does so by reacting only a small residual number of crosslink sites; thereby hardening the element without inducing significant additional chemical shrinkage. Once the product cools down after the high temperature second step, it regains the dimensions it attained during the first long end-use temperature reaction, except for insignificant additional chemical shrinkage caused by the residual crosslinking that took place at the high temperature. It is rendered insignificant by expressly inverting the proportion of chemical crosslinks that are created at each of the two temperatures.

In the method described in Kumar, et al., and others, an insignificant proportion of the crosslinking is created during the room temperature reaction and the vast majority of crosslinking is created at the elevated temperature at which the article is cured. In the process of the present invention, the opposite is true. The vast majority of crosslinking is made to take place at room temperature (by extending the time at that temperature to many days or weeks) and only an insignificant proportion takes place at the higher temperature at which the article is cured.

In reviewing the instant specification and the Kumar, et al. reference cited, certain general similarities do exist, however the specific details of Applicant's invention result in a substantial difference. It is in those differences that the patentability of the present invention resides. The specificities embodied within the instant invention and the lack of relevant disclosure in the Kumar, et al reference render the Kumar, et al. reference an inappropriate reference with respect to Applicant's invention. The Examiner has applied the rejection using the references discussed above, using selective combinations to render obvious the invention without recognizing the substantial differences that exist.

Applicants concede that Kumar, et al. do describe the use of polydimethyl siloxane, just as Applicant does. However Kumar, et al. cure the composition in a very different way, and a way that by their own admission would result in shrinkage (column 8 lines 15-30). Again, this is the substantial difference in kind and not in degree which is necessary to establish "invention."

Sangokoya, similarly to Kim, et al., discloses an entirely different class of materials. These are aluminoxane derivatives and siloxy-aluminoxane materials used to enhance catalytic effect for polymerization. The reference speaks in general terms of reaction temperatures being in the range of 25 °C to 150 °C, but Sangokoya says nothing about tailoring curing conditions to precisely define the dimension and geometry of molded parts from these materials.

And more specifically, Sangokoya does not mention two step curing, or does he mention long carefully-controlled end-use temperature cures followed by high temperature hardening steps.

Kumar, et al. acknowledge their method will cause shrinkage, but offer no way to eliminate or minimize it. Indeed, they rationalize this by claiming shrinkage is desirable because it further miniaturizes the pattern. The standard practice in applications of this type, one does not seek to further miniaturize a pattern beyond what the optical mask defined when making the mold "master." Indeed, except in specialized rare cases such changes are highly problematic.

The method of the present invention offers a way to significantly reduce and at best totally eliminate such changes. The ability to reproduce results from method end product to method end product is achieved, which is not the case in the prior art alone or in combination.

Kumar, et al. use a 2-step cure only in the extreme and broadest sense that they leave the precursor for an hour or so at room temperature after casting before putting it into high temperature oven. Such a time (i.e., one hour) will not result in a fixing of the pattern dimension, but only in establishing the shape and pattern. Applicant emphasizes that his purpose is to gain control over single-digit micrometers in dimension over a total dimension of tens of inches. He seeks such control over these phenomenal scale ratios because of the need for registration of one microscopic circuit pattern with another in a different layer of the circuit which in the example case, are pixels and associated “TFTs”(Thin Film Transistor) and wiring on a flat panel display.

Applicant uses PRECISE control of temperature DURING the “room temperature” stage of the cure. Applicant uses the term “room temperature,” but this is the end-use temperature, which is held very constant in a semiconductor clean-room setting. The molding is to be done at that precisely held and maintained temperature. In order to do so, it is necessary to do the curing either in such a temperature controlled environment as a clean room (e.g. make the stamps in a clean room where they will ultimately be used in microcontact printing operations) OR be kept under tightly controlled temperature conditions by hermetic sealing and immersion in a temperature controlled fluid bath.

As to the reference to Sangokoya, it bears no relation to the present invention. Sangokoya, similarly to Kim, et al., discloses an entirely different class of materials. These are aluminoxane derivatives and siloxy-aluminoxane materials used to enhance catalytic effect for polymerization. The reference speaks in general terms of reaction temperatures being in the range of 25 °C to 150 °C, but Sangokoya says nothing about tailoring curing conditions to precisely define the dimension and geometry of molded parts from these materials.

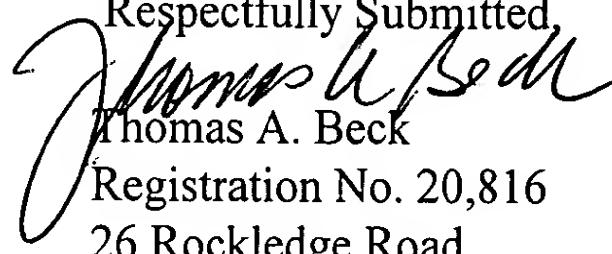
And more specifically, Sangokoya does not mention two step curing, or does he mention long carefully-controlled end-use temperature cures followed by high temperature hardening steps.

Applicant respectfully submit that the specificity of the Kim, et al. Rosato reference and Kumar references do not rise to the level required to qualify as an appropriate reference with respect to Applicant's invention.

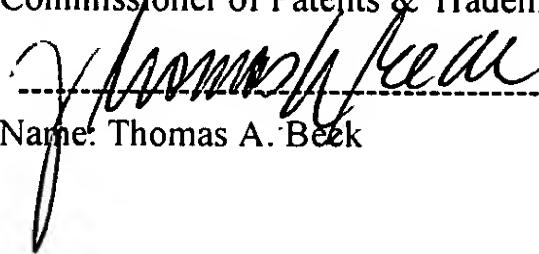
Further, the reference must describe the applicant's claimed invention sufficiently to have placed a person of ordinary skill in the field of the invention in possession of it. (Citations omitted) In re Lonnie T. Spada et al., 911 F.2d 705, 708 (Fed. Cir. 1990)

Applicant has attempted to respond to the Examiner's comments with respect to elements disclosed in the specification which distinguish the instant invention over the prior art but which elements are not in the claims. These elements so noted by the Examiner have been inserted into the claims.

In view of the amendments and cancellations made herein, Applicant believes that the claims are in condition for allowance. However if there are issues arising by virtue of this amendment which could be resolved by a telephone conference, Applicant's attorney would be pleased to speak with the Examiner concerning such matter(s) at a mutually convenient time. The Examiner is requested to contact Applicant's attorney by telephone.

Respectfully Submitted,

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I hereby certify that this paper is being mailed via First Class Mail postage prepaid on the date listed below addressed to Commissioner of Patents & Trademarks, Post Office Box 1450, Alexandria, VA 22313-1450.

 May 28, 2004
Name: Thomas A. Beck

CLAIMS (with indication of status):

1. (Currently amended) A method of making a stamp for microcontact printing, said method substantially eliminating pattern distortion of said stamp formed as a result of said method, comprising:

injection molding inserting an blend of polysiloxane oligomer-siloxane monomer elastomer reactive-mix into an enclosed mold;

retaining said blend of polysiloxane oligomer-siloxane monomer elastomer reactive-mix in said enclosed mold to maintain a precise dimension during a two phase curing process comprising: substantially curing and crosslinking said blend of polysiloxane oligomer-siloxane monomer elastomer reactive mix in said enclosed mold for a period of time ranging from in excess of one hour to one week and beyond, at a substantially constant temperature to form an article, said constant curing temperature also being the end-use temperature of a stamp to be formed from said article formed from said blend of polysiloxane oligomer-siloxane monomer elastomer reactive mix, wherein the pattern geometry of an said article so-formed is fixed at end-use thermal conditions and is not distorted;

followed by a subsequent cure of said substantially cured blend of polysiloxane oligomer-siloxane monomer elastomer reactive mix in said enclosed mold at a temperature of from between about 50 °C and 120 °C, which curing temperature is higher than said substantial end-use temperature of said stamp to be formed from said article formed from said blend of polysiloxane oligomer-siloxane monomer elastomer reactive mix and is sufficient to provide required dimensional integrity for pattern faithfulness and said subsequent cure is sufficient to harden said elastomer reactive mix to a desired elastic modulus,

said two phase curing in said enclosed mold preventing permanent shrinkage of said stamp to be formed from said cured article formed from said siloxane polymeric elastomer reactive mix;

removing said cured article formed from said blend of polysiloxane oligomer-siloxane monomer elastomer reactive mix from said enclosed mold after completion of said two phase curing

process and forming a microcontact printing stamp therefrom, said microcontact printing stamp, as a result of said two phase curing steps in said enclosed mold having minimal pattern distortion, being a flexible and soft elastomeric stamp.

.2.(Cancelled) The method of making a stamp for microcontact printing defined in claim 1 wherein said elastomer reactive material is a siloxane.

3. (Cancelled) The method of making a stamp for microcontact printing defined in claim 2 wherein said said siloxane is cured to fix its geometry while at or near the intended final use temperature, followed by a higher temperature step to harden said siloxane, without substantially inducing geometry changes to said stamp and pattern.

4. (Currently Amended) The method of making a stamp for microcontact printing defined in claim 2 wherein said blend of polysiloxane oligomer-siloxane monomer elastomer reactive mix in said enclosed mold is a vinyl addition-type siloxane two-component mixture.

5. (Cancelled) The method of making a stamp for microcontact printing defined in Claim 2 wherein said siloxane is room temperature curable.

6. (Cancelled) The method of making a stamp for microcontact printing defined in claim 1 wherein said elastomer reactive material is selected from the group consisting of siloxane systems, epoxy systems, acrylate systems, polyurethane systems, polyphosphazine systems, styrene copolymers.

7. (Currently Amended) The method of manufacturing a flat panel display where thin film transistor (TFT) and wiring dimensions contained therein are microscopically small and registration of subsequent layers of such display is within microns over many inches, using the method defined in Claim 4.

8) (Previously presented) The method of manufacturing a microelectronic pattern using the method defined in Claim 1.

9) (Currently Amended) The method of making a stamp for microcontact printing as defined in Claim 6 4 wherein said siloxane system contains momomeric moieties selected from the group consisting of hexamethylcyclotrisiloxane, octamethylcyclotrisiloxane, decamethylcyclotrisiloxane, octaphenylcyclotetrasiloxane, diphenylsilanediol, trimethyltriphenylcyclotrisiloxane, vinylmethylcyclosiloxanes, trifluoropropylmethylcyclosiloxanes, methylhydrocyclosiloxane, hexamethyldisiloxane, divinyltetramethyldisiloxane, tetramethyldisiloxane.

10) (Currently Amended) The method of making a stamp for microcontact printing as defined in Claim 6 4 wherein said siloxane system comprises polydimethyl siloxane oligomers with silyl vinyl groups (— Si — C = CH₂) and polydimethyl siloxane oligomers with silicon hydride groups having the formula:



wherein R, R', R'' are methyl and phenyl, vinyl and hydrogen, which will react with the vinyl groups in the presence of a catalyst to cross-link into a rubber material.